

## DEVELOPMENT OF STRAWBERRY AND PINEAPPLE FRUIT RIPPLE PREMIX USING RESPONSE SURFACE METHODOLOGY

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### ABSTRACT

Strawberry and pineapple fruit ripple premix were developed by implementing Response Surface Methodology (RSM) by using fruit ripple premix base, fruit powders, titbits, flavours and colors. The strawberry fruit ripple and pineapple fruit ripple were then analysed for viscosity, pH, water activity, total soluble solids and sensory attributes. The effect of changes in the concentration of variables on responses of the fruit ripple was determined by using significant regression model. The coefficient of determination,  $R^2$  of all the response variables were higher than 0.8. The optimized formulation given by RSM, based on response surfaces and superimposed plots, was further analysed for sensory analysis and physicochemical properties. The optimized solution for strawberry fruit ripple premix consisted of 27g (fruit ripple premix base), 12g (strawberry fruit powder), 1.05g (strawberry tit bits), 0.005g (color) and 0.016g (strawberry flavour powder). Similarly for preparation of pineapple fruit ripple premix the optimum solution consisted of 30.99g (fruit ripple premix base), 16g (pineapple fruit powder), 1.18g (pineapple tit bits), 0.009g (color) and 0.011g (pineapple flavour powder).

**KEYWORDS:** Fruit Ripple Premix, Response Surface Methodology, Fruit Powder, Fruit Titbits

### INTRODUCTION

Fruit ripples with bakery or frozen desert product can be the best concoction from consumer perspective. Fruit ripples are used as filling/toppings in bakery and frozen products. For preparation of fruit ripples at industrial level, whole fruit, fruit pieces, fruit purees or fruit concentrates along with combination of sweeteners, gums/ stabilisers and acid are used (Pichler et al., 2012). Hydrocolloids are widely used for manufacturing of fruit fillings with a main functional property to stabilise the insoluble particles, to increase viscosity and also improve the consistency (Young et al., 2003) with an added advantage of limiting formation of ice crystals in the frozen products (Fernandez et al, 2007). Simple sugar apart from providing sweetness it alters polysaccharide gel properties, by stabilising junction zones and increasing melting temperature. Typically for hydrocolloids, high sugar concentrations (55–70%) stabilise the junction zones within the gel network by a complex mixture of hydrogen bonds, hydrophobic and electrostatic interactions. Among the tropical fruits, strawberry (*Fragaria Rosaceae*) and pineapple (*Ananas comosus*) are the most appreciated by consumers and has prominent position in the world market. Also these are more preferred as a major object of research studies (Pelegrine et. al., 2002). Due to its good acceptability and high perishability, the development and characterization fruit ripple premix would be interesting to be used by the food industry as a topping/filling or in the formulation of new products.

At present, no studies on the optimization of the formulation of strawberry and pineapple fruit ripple premix have been published. Although the amounts of ingredient have been recommended in various articles, no scientific study for optimization of the basic formulation has been previously reported. The effectiveness of RSM in optimization of ingredient levels, formulations and processing conditions in food technology from raw to final products have been documented by different researchers. RSM consists of a group of mathematical and statistical procedures that can be used to study the relationships between one or more responses (dependent variables) and factors (independent variables) (Murphy et. al., 2003). RSM is also a useful tool to minimize the numbers of trials and provide multiple regression approach to achieve optimization. Therefore, the objective of the study is to optimize the basic formulations for the strawberry and pineapple fruit ripple premix using response surface methodology.

## MATERIALS AND METHODS

### Materials

Low-methoxy apple pectin, xanthan gum and guar gum were purchased from M/s. Gulati, Delhi with a moisture content of 12, 11 and 12%, respectively which was determined by hot air oven method (AOAC, 2000). Fruit powders (strawberry and pineapple) and fruit titbits (strawberry and pineapple) were supplied by M/s Aarkay food products Ltd., Ahmedabad, Gujarat and M/s Yeshraj Enterprises, Pune, Maharashtra respectively. Strawberry pulp (4.9 °Brix), pineapple pulp (10 °Brix), glucose powder, citric acid were procured from M/s. Gulati, Delhi. Colors (Panceau- E124, Tartrazine- E102) and flavour powder (strawberry and pineapple) were purchased from M/s. Ganapati additives pvt.ltd., Delhi.

### Control Fruit Ripple

Control strawberry fruit ripple was prepared by mixing 430g of strawberry pulp, 500g of pulverized sugar, 30g of corn flour, 1g of citric acid and 30 ml of water followed by heating to 75°C and cooling to room temperature. Similar level of ingredients and procedure was followed for preparation of control pineapple fruit ripple except 480g of pulverized sugar and 50 ml of water were used.

### Experimental Design

RSM was used to determine the experimental design and to optimize ingredient levels in fruit ripple premix. Experimental central composite (face-centered) design was done by using Design Expert (DX) version 6 with three coded levels. The RSM was done in two phases. For optimisation of strawberry and pineapple fruit ripple premix, fruit ripple premix base was used as mentioned in previous work by Nalawade et. al. (2014) which comprised of xanthan gum (0.102g), pectin (0.575g), guar gum (0.030g), sugar (21.33g), citric acid (0.004g) and glucose powder (7.80g). The five basic ingredients were incorporated in RSM for premix development as follows; premix base (27-31g), fruit powder (strawberry and pineapple) (12-16g), fruit titbits (strawberry and pineapple) (1-3g), color powder (0.005-0.009g) and flavour powder (0.11-0.16g). The coded values (Table 1) were incorporated into the design and were analysed in different combinations with two blocks. The central point of the design was repeated eight times to calculate the reproducibility of the method. The effect of independent variables on the responses (Y) was modelled using the second-order polynomial response surface. The equation derived using RSM for the prediction of the response variables is as follows:

$$Y = \beta_0 + \beta_1A + \beta_2B + \beta_3C + \beta_4D + \beta_5E + \beta_{11}A^2 + \beta_{22}B^2 + \beta_{33}C^2 + \beta_{44}D^2 + \beta_{55}E^2 + \beta_{12}A.B + \beta_{13}A.C + \beta_{14}A.D + \beta_{15}A.E + \beta_{23}B.C + \beta_{24}B.D + \beta_{25}B.E + \beta_{34}C.D + \beta_{35}C.E + \beta_{45}D.E + \varepsilon \quad \dots 1$$

Where,  $\beta_0$  is the value of the fixed response at the central point of the experiment that is the point (0, 0);  $\beta_1, \beta_2, \beta_3, \beta_4$

and  $\beta_5$  are the linear;  $\beta_{11}, \beta_{22}, \beta_{33}, \beta_{44}$  and  $\beta_{55}$  are the quadratic;  $\beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}, \beta_{23}, \beta_{24}, \beta_{25}, \beta_{34}, \beta_{35}$  and  $\beta_{45}$  are the interactions regression terms.

### Viscosity of Fruit Ripple

Viscosity of the strawberry and pineapple fruit ripple was measured by using Modular Compact Rheometer (MCR) (Model MCR52, Anton Paar GmbH, Austria, Europe). The measurements were taken in triplicate by direct yield measurement program. The measurements were taken at 10°C with plate-plate geometry probe and a 50 mm diameter (PP50) probe with a gap of 1 mm between surface and the probe. Before commencement of measurement, the sample was left to stabilize between the plates for 10 min. Ramp logarithmic profile was used with shear rate 0.1 to 100 s<sup>-1</sup> as mentioned by Basu, and Shivhare, (2010).

### Physico-Chemical Properties

Strawberry and pineapple fruit ripple premix were analysed for fat, protein, carbohydrate moisture and ash content. Fat content was determined by using Soxhlet method, protein with Kjeldahl method (Distillation unit Model: KjelFlex K-360 and Digestion unit model: Seed Digester K-439, Butchi, Switzerland, Automatic Titrator unit model: 877 Titrimo, Metrohm, Switzerland)(AOAC, 2000). Moisture content of premix sample was determined using hot air oven method (AOAC, 2000) (M/s Alfa instruments, Delhi). The ash content of fruit ripple premix was determined using muffle furnace (M/s Macro Scientific Works Pvt. Ltd., Delhi)(AOAC, 2000). Total carbohydrate was calculated by deducting the sum of the values for moisture, crude protein, crude fat, crude fibre and ash from 100 (Raghumulu, 1983). The energy value of the sample was calculated by formula (Raghumulu, 1983),

$$\text{Energy value (kcal)} = 4 (\text{protein}) + 9 (\text{fat}) + 4 (\text{carbohydrate})$$

pH is the critical attribute that mainly affects the consistency of the fruit ripple. pH analysis was done for freshly prepared and freeze thaw sample by using Digital pH meter (M/s. Systronic, Ahmedabad, India). The total soluble solids (TSS) of the freshly prepared and the freeze thaw ripple samples was estimated using handheld refractometer (HSR-500 of range 0.0-90 %, ATAGO, Japan) and was expressed as °Brix. Water activity is a useful parameter for predicting shelf life and it was measured for fruit ripple premix and the control fruit ripple prepared using fruit pulp. Water activity was determined by using Due Point Water Activity meter 4TE (Aqua Lab), having accuracy  $\pm 0.003$  and expressed as  $W_a$ .

### Sensory Analysis

The sensory evaluations of ripples were carried out on samples which were prepared and stored 10°C for 24 hrs and thawed till 25°C for 30 min prior to evaluation. The sensory panel consisted of 10 members and the evaluation sessions were held Animal product technology laboratory of NIFTEM University, Haryana, India. Color score, flavour score, texture score, and overall acceptability score of ripple samples were evaluated using nine point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely). All the samples were presented before the panellists at 25°C under normal lighting conditions in 50 ml cups coded with random, two alphanumeric numbers. Drinking water was provided for oral rinsing. At each session, the panellists evaluated 3–5 samples. The average values of the sensory scores were used for the analysis.

## RESULTS AND DISCUSSIONS

### Optimization of Addition Level of Fruit Ripple Premix Base, Strawberry Fruit Powder, Strawberry Titbit, Flavour and Color for Preparation of Strawberry Fruit Ripple Premix

The effects of fruit ripple premix base, strawberry fruit powder, strawberry fruit titbits, strawberry powder flavour and Panceau (E-124) colour on viscosity and sensory score (colour, flavour, texture and overall acceptability) of strawberry fruit ripple premix were recorded as responses (Table 2). The independent and dependent variables were fitted to the second-order model equation and examined for the goodness of fit (Table 3). The results showed that the models for all the response variables were highly adequate because they have satisfactory levels of  $R^2$  (80%) and that there is no significant lack of fit in all the response variables. The multiple regression equation generated for viscosity (Eq. 2) is mentioned as follows:

$$\begin{aligned} \text{Viscosity} = & 0.55 + 0.059(A) - (0.065)B - 0.002(C) + 0.0005(D) - 0.006(E) + 0.033(A^2) + 0.032(B^2) + 0.010(C^2) \\ & + 0.012(D^2) + 0.011(E^2) + 0.001(A.B) - 0.002(A.C) + 0.004(A.D) - 0.001(A.E) + 0.005(B.C) - 0.0008(B.D) + 0.005(B.E) - \\ & 0.003(C.D) - 0.004(C.E) - 0.0008(D.E) \end{aligned} \quad \dots 2$$

F-value of linear term process variable premix base ( $P \leq 0.001$ ) had significant effect on viscosity of strawberry fruit ripple (Table 3). Increase in addition rate of fruit powder significantly decreased the viscosity of fruit ripple while other terms were not significant ( $P > 0.05$ ). Viscosity increased with increase in concentration of fruit ripple premix base, as it contained gums (Figure 1) which are capable of increasing the viscosity. Similar rise in viscosity was reported by Basu and Shivhare, (2010) for mango jam, Agudelo et al., (2014) for modified waxy corn starch, Chantaro and Pongsawatmanit, (2010) for tapioca starch and xanthan gum mixture. As described by various scientists, viscosity of emulsions is directly proportional to the viscosity of continuous phase and therefore any components within the aqueous phase that enhance its viscosity will also influence the overall rheology of the system (Chung and McClements, 2014). The multiple regression equation generated for colour score (Eq. 3) is mentioned as follows:

$$\begin{aligned} \text{Colour score} = & 6.05 - 0.023(A) - 0.27(B) + 0.069(C) - 0.65(D) + 0.069(E) + 0.22(A^2) + 0.22(B^2) + 0.046(C^2) - \\ & 0.042(D^2) + 0.046(E^2) - 0.031(A.B) + 0.031(A.C) + 0.031(A.D) + 0.031(A.E) - 0.031(B.C) + 0.22(B.D) - 0.031(B.E) - \\ & 0.094(C.D) - 0.094(C.E) - 0.094(D.E) \end{aligned} \quad \dots 3$$

Addition of fruit powder and panceu color over a certain addition level had a significant negative effect on colour score of the strawberry ripple (Figure 2). Increase in concentration of colour and/or fruit powder causes increase in darkness of ripple which decreased score for colour. Same effects were observed by Christophe et al. (2013) and by Igual et al. (2014). The reason may be attributed to the continuous phase characteristics of the strawberry fruit ripple in which the optical properties are depended upon their ability to scatter or absorb light waves. Incorporation of non-fat particles that scatter light in similar manner to oil droplets increased the opacity of emulsions e.g. protein micro-particulates, skim milk powder, gums (Chung and McClements, 2014).

$$\begin{aligned} \text{Flavour score} = & 6.03 - 0.078(A) - 0.078(B) - 0.12(C) - 0.023(D) + 0.17(E) + 0.12(A^2) + 0.12(B^2) + 0.12(C^2) + \\ & 0.21(D^2) - 0.060(E^2) - 0.031(A.B) + 0.031(A.C) - 0.031(A.D) - 0.094(A.E) + 0.031(B.C) - 0.031(B.D) - 0.59(B.E) + \\ & 0.031(C.D) - 0.16(C.E) - 0.094(D.E) \end{aligned} \quad \dots 4$$

$$\begin{aligned} \text{Texture score} = & 6.99 - 0.59(A) - 0.22(B) + 0.023(C) - 0.023(D) + 0.023(E) - 0.10(A^2) - 0.10(B^2) - 0.012(C^2) - \\ & 0.012(D^2) - 0.012(E^2) + 0.22(A.B) - 0.031(A.C) + 0.031(A.D) - 0.031(A.E) - 0.031(B.C) + 0.031(B.D) - 0.031(B.E) + \end{aligned}$$

$$0.031(C.D) - 0.031(C.E) + 0.031(D.E)$$

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Score of flavour for strawberry fruit ripple increased significantly with increase in strawberry flavour powder while opposite trend was obtained for strawberry titbits (Eq. 4, Figure 3). Non-fat particles and other components within the aqueous phase may have influenced the perceived flavour characteristics of emulsion-based products and their ability to alter the portioning and mass transfer of volatile and non-volatile molecules. Thickening or gelling agents can delay diffusion of flavour molecules to the taste score receptor on the tongue and hence affect the flavour profile of fruit ripple (Chung and McClements, 2014). Increase in the concentration of fruit premix base decrease the score for of texture significantly (Eq. 5, Figure 4). Presence of gums and stabilisers in fruit ripple premix base increases the viscosity and affects the texture of the strawberry fruit ripple. Same results were obtained by Belgin et al.(2003)for set yoghurt and by Fernandez et al.(2007), Pichler et al. (2012), Christophe et al.(2013)and by Igual et al. (2014). The strawberry fruit powder imparts graininess which in turn affected the textural score of the strawberry ripple.

$$\begin{aligned} \text{Overall acceptability score} = & 6.04 - 0.29(A) - 0.29(B) + 0.10(C) - 0.29(D) + 0.29(E) + 0.30(A^2) + 0.21(B^2) + \\ & 0.12(C^2) + 0.12(D^2) + 0.12(E^2) + 0.062(A.B) + 0.000(A.C) - 0.13(A.D) + 0.000(A.E) - 0.063(B.C) + 0.062(B.D) - \\ & 0.31(B.E) + 0.000(C.D) - 0.13(C.E) + 0.000(D.E) \end{aligned}$$

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Overall acceptability score of strawberry fruit ripple increased significantly with increase in strawberry flavour powder ( $P \leq 0.001$ ), while it decreased significantly with increase in addition level of fruit ripple premix base, strawberry powder and panceu color (Table 3). Further all quadratic term of premix had positive significant effect on overall acceptability score of fruit ripple. The interaction term fruit powder-flavour ( $P \leq 0.001$ ) and premix base-colour powder ( $P \leq 0.05$ ) had significant negative effect on the overall acceptability score while other interaction terms were not significant ( $P > 0.05$ ) (Figure 5 and 6).

The compromised optimum condition for the development of strawberry premix was then determined using Design expert Software (DX 6). Compromised optimum condition applied for numerical technique optimization were maximum for colour score, flavour score, texture score and overall acceptability score and viscosity targeted to 0.669Pa.s. The compromised optimum conditions obtained for the development of strawberry fruit ripple premix is presented in Table 5.

The calculated values of responses and the predicted values for compromised optimum solutions given by RSM are tabulated in Table 5. There was very less deviation in calculated values of responses and the predicted values for compromised optimum solution no 1. Thus, finalised optimum solution for preparation of strawberry fruit ripple premix consisted of 27g (fruit ripple premix base), 12g (strawberry fruit powder), 1.05g (strawberry tit bits), 0.005g (color) and 0.016g (strawberry flavour powder).

### **Optimization of Addition Level of Fruit Ripple Premix Base, Pineapple Fruit Powder, pineapple Titbit, Flavour and Color for Preparation of Pineapple Fruit Ripple Premix**

The effects of fruit ripple premix base, pineapple fruit powder, pineapple fruit titbits, pineapple powder flavour and Tartrazine (E-102) color on viscosity and sensory attributes of pineapple fruit ripple premix was studied using RSM (Table 4). Lack of fit and the significance of the linear, quadratic and interaction effects of the independent variables on the dependent variables were determined from analyses of variance (Table 4). The results showed that the models for all the response variables were highly adequate because they have satisfactory levels of  $R^2$  of more than 80% and that there is no

significant lack of fit in all the response variables.

$$\begin{aligned} \text{Viscosity} = & 0.71 + 0.031(A) - 0.065(B) - 0.007(C) - 0.004(D) + 0.005(E) + 0.009(A^2) + 0.023(B^2) + 0.024(C^2) + \\ & 0.006(D^2) + 0.006(E^2) + 0.042(A.B) + 0.003(A.C) + 0.007(A.D) - 0.002(A.E) + 0.015(B.C) + 0.007(B.D) - 0.009(B.E) - \\ & 0.011(C.D) + 0.011(C.E) + 0.007(D.E) \end{aligned} \quad \dots 7$$

From Table 3 and Eq. 7, it is evident that as the concentration of the fruit ripple premix base increased it also increased the viscosity of pineapple fruit ripple. Increase in viscosity in different fruit preparations may be attributed to the presence of gums and the results obtained the present study are in full agreement with those reported by Basu and Shivhare, (2010), Agudelo et al. (2014), Chantaro and Pongsawatmanit, (2010), with tapioca starch and xanthan gum mixture by Ahmed et al. (2005). Similarly with increase in concentration of pineapple fruit powder it caused significant decrease in viscosity of pineapple fruit ripple. The reason for change in viscosity may be the same as mentioned in 3.1.

$$\begin{aligned} \text{Colour score} = & 7.02 + 0.000(A) + 0.29(B) + 0.046(C) + 0.56(D) - 0.046(E) + 0.020(A^2) - 0.069(B^2) + 0.020(C^2) - \\ & 0.25(D^2) + 0.020(E^2) + 0.000(A.B) + 0.000(A.C) + 0.000(A.D) + 0.000(A.E) + 0.062(B.C) + 0.19(B.D) - 0.063(B.E) - \\ & 0.063(C.D) - 0.063(C.E) + 0.062(D.E) \end{aligned} \quad \dots 8$$

Pineapple fruit powder and tartrazine color increased the colour score of pineapple fruit ripple significantly ( $P \leq 0.001$ ) and from Figure 8 and Eq. 8, it was observed that colour score increased with the concentration of the tartrazine color and pineapple fruit powder within limit.

$$\begin{aligned} \text{Flavour score} = & 6.03 - 0.078(A) - 0.078(B) - 0.12(C) - 0.023(D) + 0.17(E) + 0.12(A^2) + 0.12(B^2) + 0.12(C^2) + \\ & 0.21(D^2) - 0.060(E^2) - 0.031(A.B) + 0.031(A.C) - 0.031(A.D) - 0.094(A.E) + 0.031(B.C) - 0.031(B.D) - 0.59(B.E) + \\ & 0.031(C.D) - 0.16(C.E) - 0.094(D.E) \end{aligned} \quad \dots 9$$

$$\begin{aligned} \text{Texture score} = & 6.99 + 0.61(A) + 0.24(B) + 0.000(C) + 0.000(D) + 0.000(E) - 0.27(A^2) + 0.080(B^2) - 0.008(C^2) - \\ & 0.008(D^2) - 0.008(E^2) + 0.25(A.B) + 0.000(A.C) + 0.000(A.D) + 0.000(A.E) + 0.000(B.C) + 0.000(B.D) + 0.000(B.E) + \\ & 0.000(C.D) + 0.000(C.E) + 0.000(D.E) \end{aligned} \quad \dots 10$$

$$\begin{aligned} \text{Overall acceptability score} = & 6.04 - 0.29(A) - 0.29(B) + 0.10(C) - 0.29(D) + 0.29(E) + 0.30(A^2) + 0.21(B^2) + \\ & 0.12(C^2) + 0.12(D^2) + 0.12(E^2) + 0.062(A.B) + 0.000(A.C) - 0.13(A.D) + 0.000(A.E) - 0.063(B.C) + 0.062(B.D) - \\ & 0.31(B.E) + 0.000(C.D) - 0.13(C.E) + 0.000(D.E) \end{aligned} \quad \dots 11$$

Pineapple flavour powder increased the flavour score significantly ( $P \leq 0.01$ ) while opposite was true for addition of pineapple fruit powder (Figure 9 and Eq. 9). Linear term fruit ripple premix base had a positive significant effect ( $P \leq 0.001$ ) on the texture score of strawberry fruit ripple premix (Figure 10 and Eq. 10). Presence of gums contributed to the increased texture score and the same was reported by Belgin et al. (2003) for set yoghurt, Fernandez et al. (2007), Pichler et al. (2012), Christophe et al. (2013) and by Igual (2014). Apart from fruit ripple premix base, pineapple fruit powder also increased the texture score significantly ( $P \leq 0.001$ ). The overall acceptability score of pineapple fruit ripple increased significantly with increase in fruit ripple premix base, pineapple titbits and tartrazine color while opposite trend was observed for tartrazine colour. The interaction term fruit ripple premix base- pineapple fruit powder, fruit ripple premix base- pineapple flavour powder, pineapple fruit powder-colour ( $P \leq 0.001$ ), fruit ripple premix base-pineapple titbits ( $P \leq 0.05$ ) had significant positive effect while pineapple fruit powder-pineapple titbits and pineapple fruit powder-pineapple flavour powder had significantly negative effect on the overall acceptability score (Figure 11 and 12). The reason may be attributed to the fact that gums when used as a functional ingredient in a food system, they are often

responsible for affecting the structure, appearance, texture score, viscosity, mouth feel, or flavour retention property (Morr and Ha, 1993).

The compromised optimum condition for the development of pineapple premix was then determined using Design expert Software (DX 6) with a maximum for sensory attributes and targeted viscosity of 0.669 Pa.s. The compromised optimum conditions obtained for the development of pineapple fruit premix are presented in Table 6. The calculated values of responses and the predicted values for compromised optimum solutions given by RSM are tabulated in Table 6. There was very less deviation in calculated values of responses and the predicted values for compromised optimum solution no 1. Hence the finalised optimum solution for preparation of pineapple fruit ripple premix consisted of 30.99g (fruit ripple premix base), 16g (pineapple fruit powder), 1.18g (pineapple tit bits), 0.009g (color) and 0.011g (pineapple flavour powder).

### Physico-Chemical Properties

Freshly prepared and freeze-thawed strawberry and pineapple ripple was analysed for viscosity, pH, total soluble solids and water activity. The purpose behind the analysis was to report any changes in the properties as an effect of storage under cold condition after preparation of fruit ripple and thereby evaluate its stability (Table 7). Freshly prepared strawberry and pineapple ripple were non-significantly different from control ripple in respect to their physico-chemical properties. However, increased viscosity and decreased pH and  $w_a$  was observed in freeze thawed sample of strawberry and pineapple ripple as compared to freshly prepared ripple. The reason behind increased viscosity in freeze thawed sample of strawberry and pineapple ripple would be low level of free water, as gums and stabilisers are fully activated during the storage time (Balestra, 2011; Banjongsinsiri, 2003; Chantaro et al., 2013). Physico-chemical properties and nutritional values of strawberry and pineapple ripple premix are represented in Table 8.

### Sensory Analysis

Average scores of sensory attributes in respect of colour, flavour, texture and overall acceptability of strawberry and pineapple fruit ripple are reported in Figure 13. The overall acceptability scores for strawberry and pineapple fruit ripple ranged between 6- 7.4 and 6.2-7.7 respectively.

## CONCLUSIONS

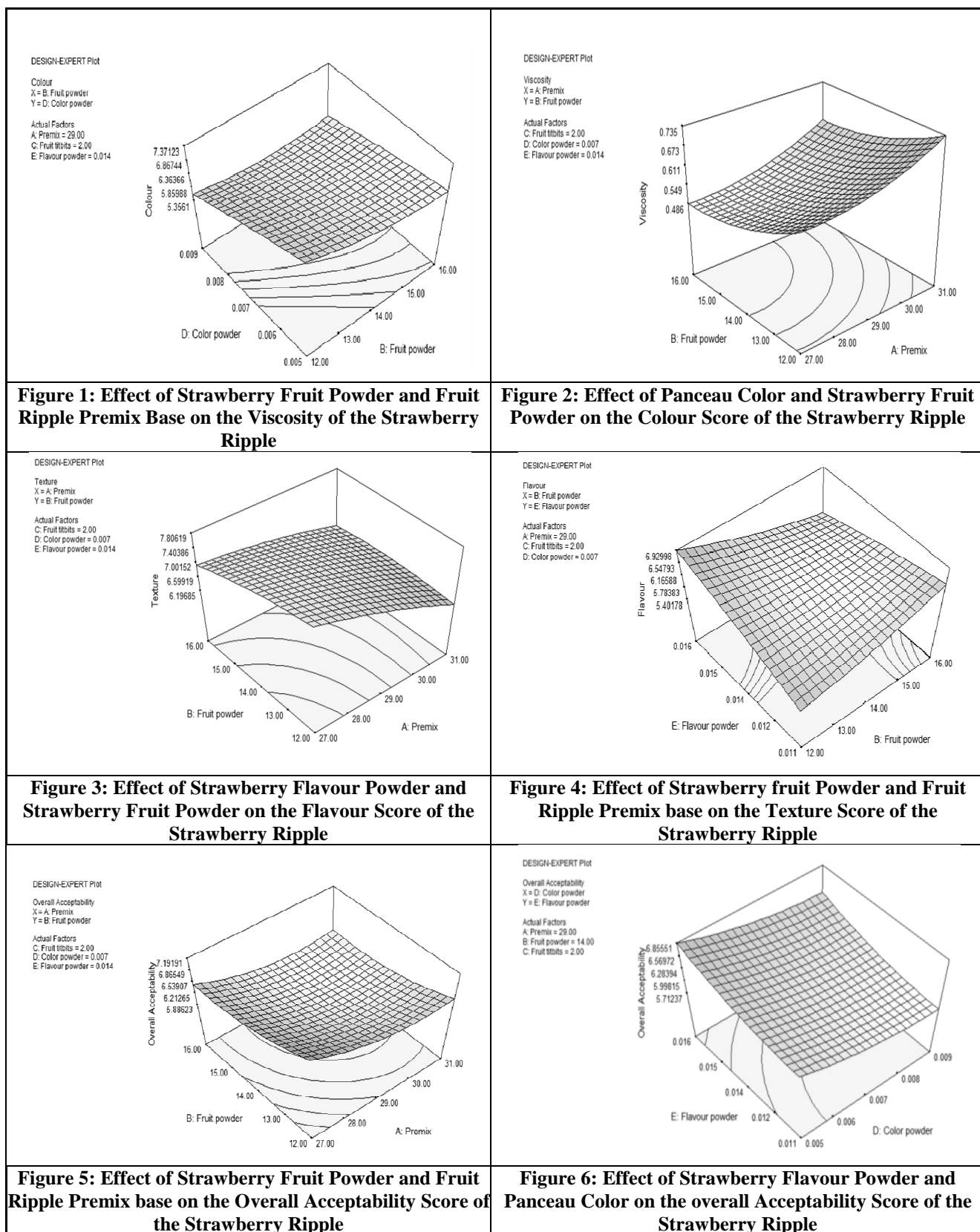
Very few studies are conducted for manufacturing of fruit ripple premixes. They are very useful for bakery and confectionary applications like fillings and toppings, etc. RSM is a useful tool in formulation and optimisation of the basic formulation of strawberry and pineapple fruit ripple premix by partial differentiating the empirical model with respect to each parameter, equating to zero and simultaneously solving the resulting functions. The final optimised solution obtained for preparation of strawberry fruit ripple premix was consisting of fruit ripple premix base (27g), strawberry fruit powder (12g), strawberry fruit tit bits (1.05g), panceucolor (0.005g) and mango flavour powder (0.016g). While, that for preparation of pineapple fruit ripple premix was consisting of fruit ripple premix base (27g), pineapple fruit powder (12g), pineapple fruit tit bits (1.05g), tartrazine color (0.005g) and pineapple flavour powder (0.016g).

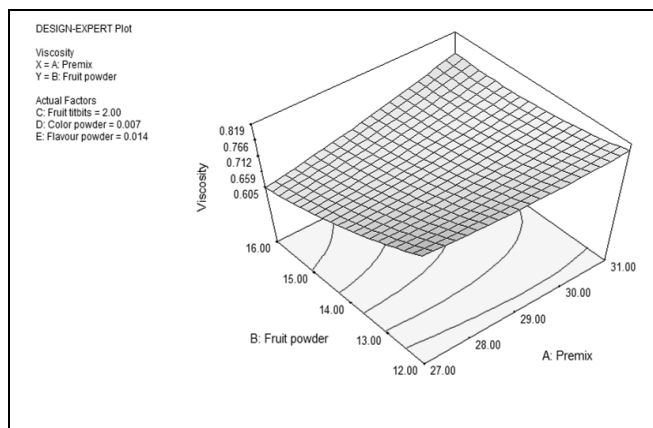
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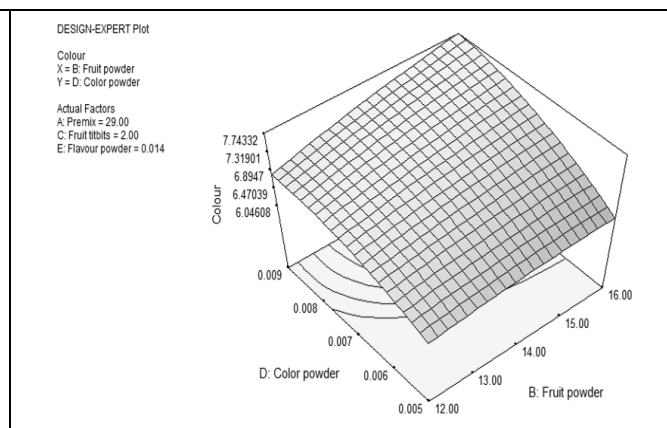
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## APPENDICES

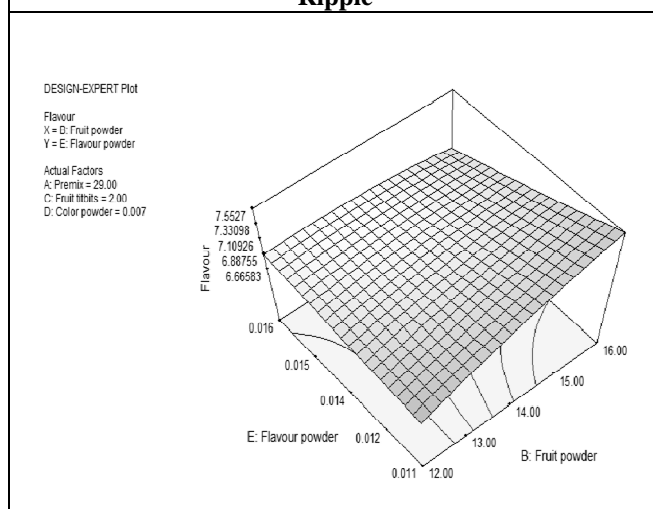




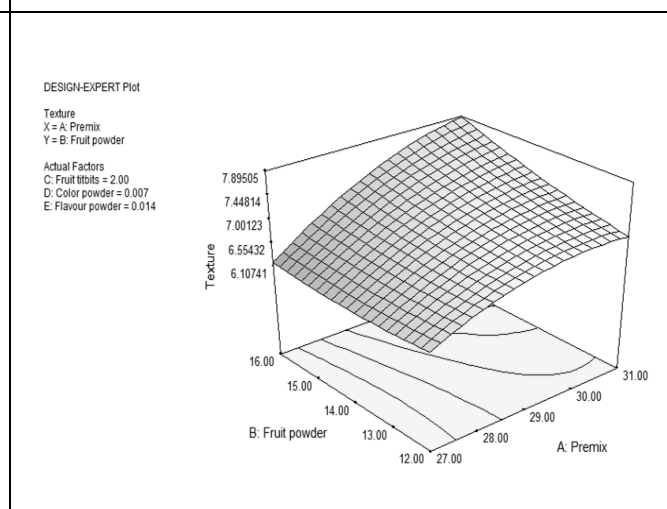
**Figure 7: Effect of Pineapple Fruit Powder and Fruit Ripple Premix base on the Viscosity of the Pineapple Ripple**



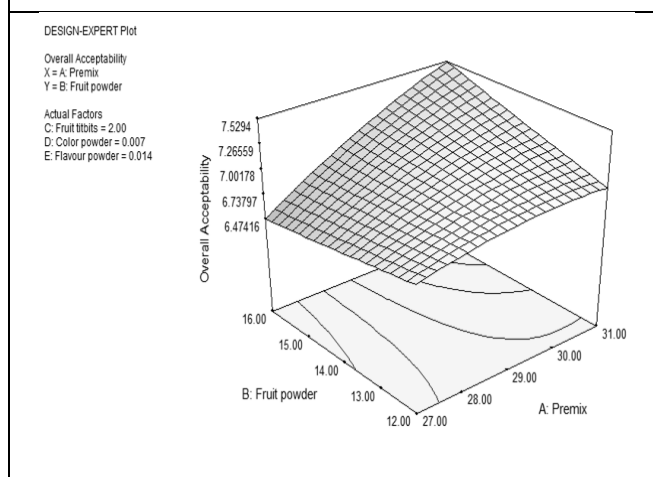
**Figure 8: Effect of tartrazine Color and Pineapple Fruit Powder on the Colour score of the Pineapple Ripple**



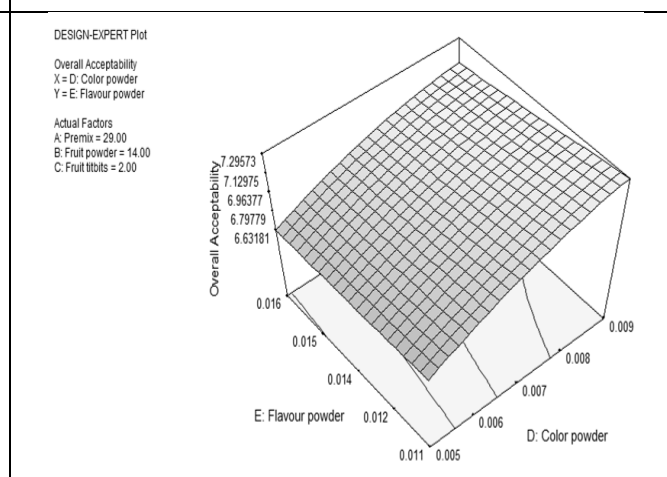
**Figure 9: Effect of Pineapple Flavour Powder and Pineapple Fruit Powder on the Flavour Score of the Pineapple Ripple**



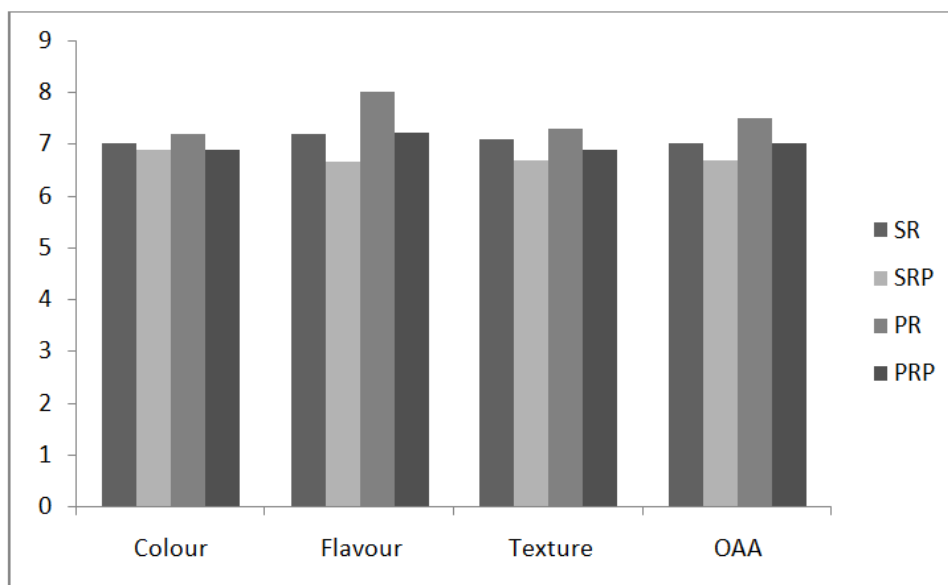
**Figure 10: Effect of Pineapple Fruit Powder and Fruit Ripple Premix base on the Texture Score of the Pineapple Ripple**



**Figure 11. Effect of Pineapple Fruit Powder and Fruit Ripple Premix base on the Overall Acceptability Score of the Pineapple Ripple**



**Figure 12. Effect of Pineapple Flavour Powder and Tartrazine Color on the Overall Acceptability Score of the Pineapple Ripple**



**Figure 13: Sensory Acceptability to Consumers of Strawberry Fruit Ripple (SR- Control, SRP- Test) and Pineapple Fruit Ripple (PR- Control, PRP- Test)**

**Table 1: Extreme Level of Independent Variables**

Independent Variable	Coded Value	Levels		
		-1	0	+1
Premix base (g)	A	27.00	29.00	31.00
Fruit powder (strawberry/pineapple) (g)	B	12.00	14.00	16.00
Fruit titbit (strawberry/pineapple) (g)	C	1.00	2.00	3.00
Color (Panceau/ Tartrazine) (g)	D	0.005	0.007	0.009
Flavour powder (strawberry/pineapple) (g)	E	0.011	0.0135	0.016

**Table 2: Codified Values of Ingredients and Corresponding Responses for Strawberry Fruit Ripple Premix**

Independent Variable					Responses				
Pre	SFP	SFT	Col.	S Fla.	V (Pa.S)	Colour Score	Fla. Score	Text. Score	OAA Score
-1	-1	-1	-1	-1	0.701	7	5	8	7
1	-1	-1	-1	-1	0.77	7	6	6	6
-1	1	-1	-1	-1	0.542	7	7	7	7
1	1	-1	-1	-1	0.679	6	7	6	7
-1	-1	1	-1	-1	0.701	8	6	8	8
1	-1	1	-1	-1	0.82	8	6	6	7
-1	1	1	-1	-1	0.548	7	7	7	7
1	1	1	-1	-1	0.671	7	7	6	7
-1	-1	-1	1	-1	0.705	6	6	7	6
1	-1	-1	1	-1	0.837	6	6	6	6
-1	1	-1	1	-1	0.542	6	7	7	7
1	1	-1	1	-1	0.667	6	7	6	6
-1	-1	1	1	-1	0.671	6	6	8	7
1	-1	1	1	-1	0.816	6	6	6	6
-1	1	1	1	-1	0.539	6	7	7	7
1	1	1	1	-1	0.682	6	7	6	6
-1	-1	-1	-1	1	0.669	8	8	8	9
1	-1	-1	-1	1	0.815	8	8	6	8
-1	1	-1	-1	1	0.536	7	7	7	7
1	1	-1	-1	1	0.659	7	6	6	7

Table 2: Contd.,

-1	-1	1	-1	1	0.664	8	7	8	8
1	-1	1	-1	1	0.75	8	7	6	8
-1	1	1	-1	1	0.548	7	6	7	7
1	1	1	-1	1	0.657	7	6	6	7
-1	-1	-1	1	1	0.661	6	8	8	8
1	-1	-1	1	1	0.819	6	7	6	7
-1	1	-1	1	1	0.541	6	6	7	7
1	1	-1	1	1	0.661	6	6	6	6
-1	-1	1	1	1	0.658	6	7	8	8
1	-1	1	1	1	0.75	6	7	6	7
-1	1	1	1	1	0.542	6	6	7	7
1	1	1	1	1	0.667	6	6	6	6
-2.37	0	0	0	0	0.53	7	7	7	8
2.378	0	0	0	0	0.79	7	6	6	7
0	-2.378	0	0	0	0.8	8	7	7	8
0	2.378	0	0	0	0.512	6	6	6	6
0	0	-2.378	0	0	0.531	6	7	7	6
0	0	2.378	0	0	0.533	6	6	7	7
0	0	0	-2.378	0	0.54	7	7	7	7
0	0	0	2.378	0	0.538	4	7	7	6
0	0	0	0	-2.378	0.532	6	5	7	6
0	0	0	0	2.378	0.533	6	6	7	7
0	0	0	0	0	0.55	6	6	7	6

Pre: Premix base, SFP: Strawberry fruit powder, SFT: Strawberry fruit titbits, Col: Colour powder, S Fla: Strawberry flavour, V: Viscosity, Fla. Score: Flavour score, Text Score: Texture score, OAA Score: overall acceptability score.

Table 3: Analysis of Variance (ANOVA) Showing the Linear, Quadratic Interaction and the Lack of Fit of the Response Variables in RSM for Strawberry Fruit Ripple Premix

S. of Var.	DF	Responses for strawberry Fruit Ripple										Responses for Pineapplefruit Ripple									
		Viscosity		Colour Score		Flavour Score		Texture Score		Overall Accep. Score		Viscosity		Colour Score		Flavour Score		Texture Score		Overall Accep. Score	
		MS	F-val.	MS	F-val.	MS	F-val.	MS	F-val.	MS	F-val.	MS	F-val.	MS	F-val.	MS	F-val.	MS	F-val.	MS	F-val.
Reg. Model	20	0.02	7.59 <sup>a</sup>	1.49	16.4 <sup>a</sup>	0.973	9.56 <sup>a</sup>	0.98	10.30 <sup>a</sup>	1.32	11.12 <sup>a</sup>	0.018	8.321 <sup>a</sup>	1.153	11.4 <sup>a</sup>	0.396	7.98 <sup>a</sup>	1.27	14.8 <sup>a</sup>	0.90	14.1 <sup>a</sup>
A	1	0.15	51.80 <sup>a</sup>	0.02	0.254	0.263	2.589	14.8	154.8 <sup>a</sup>	3.53	29.65 <sup>a</sup>	0.043	19.49 <sup>a</sup>	0	0	0	0	16.1	186.6 <sup>a</sup>	4.13	64.6 <sup>a</sup>
B	1	0.18	61.95 <sup>a</sup>	3.19	35.2 <sup>a</sup>	0.263	2.589	2.03	21.14 <sup>a</sup>	3.73	31.49 <sup>a</sup>	0.181	82.41 <sup>a</sup>	3.537	35.0 <sup>a</sup>	1.620	32.6 <sup>a</sup>	2.49	28.8 <sup>a</sup>	0.21	3.24
C	1	0.003	0.1041	0.02	2.293	0.066	6.553 <sup>a</sup>	0.02	0.241	0.04	3.709	0.002	0.971	0.092	0.914	0	0	0	0	0.04	0.68
D	1	0.0004	0.0042	18.27	2.01 <sup>a</sup>	0.023	0.226	0.02	0.24	3.53	29.65 <sup>a</sup>	0.001	0.454	13.72	135.8 <sup>a</sup>	0.09	1.86	0	0	2.98	46.7 <sup>a</sup>
E	1	0.001	0.666	0.20	2.293	1.256	12.3 <sup>a</sup>	0.02	0.241	3.53	29.65 <sup>a</sup>	0.001	0.583	0.092	0.914	0.831	16.7 <sup>a</sup>	0	0	0.21	3.24
A*	1	0.060	20.60 <sup>a</sup>	2.75	30.4 <sup>a</sup>	0.755	7.428 <sup>a</sup>	0.56	5.864 <sup>a</sup>	4.988	41.80 <sup>a</sup>	0.005	2.393	0.021	0.209	2.129	42.8 <sup>a</sup>	4.17	48.4 <sup>a</sup>	0.37	5.79 <sup>a</sup>
B*	1	0.038	19.73 <sup>a</sup>	2.75	30.4 <sup>a</sup>	0.755	7.428 <sup>a</sup>	0.56	5.864 <sup>a</sup>	2.479	20.77 <sup>a</sup>	0.030	13.67 <sup>a</sup>	0.263	2.608	0.267	5.38 <sup>a</sup>	0.35	4.11	0.01	0.03
C*	1	0.006	2.046	0.11	1.296	0.755	7.428 <sup>a</sup>	0.008	0.087	0.838	7.02 <sup>a</sup>	0.033	15.16 <sup>a</sup>	0.021	0.209	0.020	0.40	0.01	0.04	0.50	7.83 <sup>a</sup>
D*	1	0.007	2.561	0.09	1.102	2.335	22.9 <sup>a</sup>	0.008	0.087	0.838	7.02 <sup>a</sup>	0.002	0.969	3.353	33.1 <sup>a</sup>	0.020	0.40	0.01	0.04	0.37	5.79 <sup>a</sup>
E*	1	0.006	2.081	0.11	1.296	0.201	1.97	0.008	0.087	0.838	7.02 <sup>a</sup>	0.003	1.234	0.021	0.209	0.020	0.40	0.01	0.04	0.00	0.03
AB	1	0.0001	0.035	0.03	0.344	0.031	0.30	1.33	15.94 <sup>a</sup>	0.125	1.04	0.057	25.93 <sup>a</sup>	0	0	0.125	2.52	2	23.2 <sup>a</sup>	1.33	23.9 <sup>a</sup>
AC	1	0.0001	0.049	0.03	0.344	0.032	0.30	0.03	0.32	0	0	0.001	0.225	0	0	0	0	0	0	0.78	12.2 <sup>a</sup>
AD	1	0.0005	0.173	0.03	0.344	0.031	0.30	0.03	0.325	0.5	4.190 <sup>a</sup>	0.002	0.875	0	0	0.125	2.52	0	0	0.03	0.48
AE	1	0.003	0.012	0.03	0.344	0.282	2.76	0.03	0.32	0	0	0.001	0.077	0	0	0.125	2.52	0	0	1.33	23.9 <sup>a</sup>
BC	1	0.0009	0.321	0.03	0.344	0.031	0.30	0.03	0.325	0.125	1.	0.007	3.196	0.125	1.237	0.125	2.52	0	0	0.78	12.2 <sup>a</sup>
BD	1	0.002	0.007	1.53	16.8 <sup>a</sup>	0.031	0.30	0.03	0.32	0.125	1.047	0.002	0.713	1.125	11.13 <sup>a</sup>	0	0	0	0	2.53	39.5 <sup>a</sup>
BE	1	0.0009	0.328	0.03	0.344	11.28	11.0 <sup>a</sup>	0.03	0.325	3.1	26.19 <sup>a</sup>	0.003	1.402	0.125	1.237	2	40.3 <sup>a</sup>	0	0	1.33	23.9 <sup>a</sup>
CD	1	0.0002	0.097	0.28	3.10	0.031	0.307	0.03	0.325	0	0	0.004	1.722	0.125	1.237	0.125	2.51	0	0	0.03	0.48
CE	1	0.0005	0.179	0.28	3.10	0.781	7.67 <sup>a</sup>	0.03	0.325	0.5	4.19 <sup>a</sup>	0.004	1.664	0.125	1.237	0.125	2.51	0	0	0.28	4.99 <sup>a</sup>
DE	1	0.0002	0.007	0.28	3.10	0.281	2.764	0.03	0.32	0	0	0.002	0.739	0.125	1.237	0	0	0	0	0.03	0.48
Res	29	0.002		0.09	22.9	0.101	24.09	0.09	21.6	0.119	22.57	0.002	0.101	22.58	0.049	25.8	0.09	27.9	0.06	25.7	
FF	22	0.003	107.1	0.11	11.5	0.13	10.38	0.12	13.58	0.15	15.86	0.003	93.51	0.133	13.46	0.065	2.35	0.11	11.1	0.08	11.36
FE	7	0.003		-	-	-	-	-	-	-	-	0.0003	-	-	-	-	-	-	-	0	-
R <sup>2</sup>	-	-	83.97	-	91.91	-	86.84	-	86.67	-	88.47	-	85.16	-	88.73	-	84.6	-	91.1	-	88.5
Adj R <sup>2</sup>	-	-	72.92	-	86.33	-	77.76	-	79.16	-	80.51	-	74.93	-	80.96	-	74.0	-	84.9	-	80.5

Overall Accep Score: Overall acceptability score <sup>a</sup>Significant at P≤0.05; <sup>b</sup>significant at P≤0.01; <sup>c</sup>significant at P≤0.001; DF = degree of freedom

Table 4: Codified Values of Ingredients and Corresponding Responses for Pineapple Fruit Ripple Premix

Independent Variable					Responses				
Pre	PFP	PFT	Col.	P Fla.	V (Pa.S)	Colour Score	Fa. Score	Text. Score	OAA Score
-1	-1	-1	-1	-1	0.903	6	7	6	7
1	-1	-1	-1	-1	0.889	6	7	7	7
-1	1	-1	-1	-1	0.657	6	8	6	6
1	1	-1	-1	-1	0.818	6	8	8	7
-1	-1	1	-1	-1	0.89	6	7	6	6
1	-1	1	-1	-1	0.83	6	7	7	7
-1	1	1	-1	-1	0.67	7	8	6	6
1	1	1	-1	-1	0.83	7	8	8	8
-1	-1	-1	1	-1	0.91	7	7	6	7
1	-1	-1	1	-1	0.89	7	7	7	7
-1	1	-1	1	-1	0.648	8	8	6	7
1	1	-1	1	-1	0.818	8	8	8	9
-1	-1	1	1	-1	0.74	7	7	6	6
1	-1	1	1	-1	0.79	7	7	7	7
-1	1	1	1	-1	0.651	8	8	6	7
1	1	1	1	-1	0.809	8	7	8	9
-1	-1	-1	-1	1	0.903	6	7	6	7
1	-1	-1	-1	1	0.879	6	7	7	7
-1	1	-1	-1	1	0.657	6	7	6	6
1	1	-1	-1	1	0.76	6	7	8	6
-1	-1	1	-1	1	0.915	6	7	6	7
1	-1	1	-1	1	0.873	6	8	7	7
-1	1	1	-1	1	0.66	6	7	6	6
1	1	1	-1	1	0.82	6	7	8	7
-1	-1	-1	1	1	0.91	7	7	6	7
1	-1	-1	1	1	0.878	7	7	7	7
-1	1	-1	1	1	0.654	8	7	6	7
1	1	-1	1	1	0.815	8	7	8	7
-1	-1	1	1	1	0.85	7	7	6	7
1	-1	1	1	1	0.885	7	7	7	7
-1	1	1	1	1	0.651	8	7	6	7
1	1	1	1	1	0.821	8	7	8	8
-2.37	0	0	0	0	0.659	7	8	5	6
2.378	0	0	0	0	0.754	7	8	6	7
0	-2.378	0	0	0	0.91	6	6	7	7
0	2.378	0	0	0	0.656	7	7	8	7
0	0	-2.378	0	0	0.79	7	7	7	8
0	0	2.378	0	0	0.79	7	7	7	7
0	0	0	-2.378	0	0.681	5	7	7	6
0	0	0	2.378	0	0.692	6	7	7	7
0	0	0	0	-2.378	0.681	7	7	7	7
0	0	0	0	2.378	0.701	7	7	7	7
0	0	0	0	0	0.71	7	7	7	7

Pre: Premix base, PFP: Pineapple fruit powder, PFT: Pineapple fruit titbits, Col: Colour powder, PFla: Pineapple flavour, V: Viscosity, Fla. Score: Flavour score, **Text Score**: Texture score, OAA Score: overall acceptability score.

**Table 5: Compromised Optimum Conditions for Strawberry Ripple Premix Given by RSM**

No.	Pre	SFP	SFT	Col.	S Fla.	Colour Score			Fla. Score			Text. Score			OAA Score			V (Pa.s)		
						RSM	Act.	Dev.	RSM	Act.	Dev.	RSM	Act.	Dev.	RSM	Act.	Dev.	RSM	Act.	Dev.
1	27	12.00	1.05	0.005	0.016	7.8	7	0.8	7.9	7	0.9	7.8	6	1.8	8.3	8	0.3	0.65	0.52	0.12
2	27	12.00	2.41	0.005	0.016	7.8	6	1.8	7.3	6	1.3	7.9	6	1.9	8.2	6	2.2	0.63	0.50	0.13
3	27	12.00	1.07	0.005	0.016	7.6	7	0.6	7.7	6	1.7	7.5	6	1.5	8.0	6	2.0	0.65	0.52	0.12
4	27	12.00	2.81	0.005	0.016	7.7	6	1.7	7.1	6	1.1	7.9	6	1.9	8.2	6	2.2	0.63	0.50	0.12
5	29	12.14	1.00	0.005	0.016	7.5	6	1.5	7.5	6	1.5	6.8	6	0.8	7.7	6	1.7	0.68	0.81	0.13

Pre: Premix base, SFP: Strawberry fruit powder, SFT: Strawberry fruit titbits, Col: Colour powder, S Fla: Strawberry flavour, V: Viscosity, Fla. Score: Flavour score, Text Score: Texture score, OAA Score: overall acceptability score, RSM- Value from RSM, Act.- Actual calculated value, Dev.- deviation

**Table 6: Compromised Optimum Conditions for Pineapple Fruit Ripple Premix**

No.	Pre	PFP	PFT	Col.	P Fla.	Colour Score			Fla. Score			Text. Score			OAA Score			V (Pa.s)		
						RSM	Act.	Dev.	RSM	Act.	Dev.	RSM	Act.	Dev.	RSM	Act.	Dev.	RSM	Act.	Dev.
1	30.99	16.00	1.18	0.009	0.011	7.7	7	0.7	7.6	8	0.4	7.8	7	0.8	8.5	8	0.5	0.79	0.72	0.07
2	31.00	16.00	1.10	0.009	0.011	7.7	6	1.7	7.6	7	0.6	7.8	7	0.8	8.4	8	0.4	0.80	0.87	0.07
3	31.00	16.00	2.20	0.009	0.011	7.8	6	1.8	7.5	7	0.5	7.8	7	0.8	8.5	8	0.5	0.77	0.85	0.08
4	31.00	14.88	1.01	0.009	0.011	7.5	7	0.5	7.5	6	1.5	7.5	6	1.5	8.1	7	1.1	0.80	0.87	0.07
5	30.67	16.00	2.09	0.009	0.011	7.8	6	1.8	7.4	6	1.4	7.8	6	1.8	8.4	7	1.4	0.75	0.67	0.08

Pre: Premix base, PFP: Pineapple fruit powder, PFT: Pineapple fruit titbits, Col: Colour powder, P Fla: Pineapple flavour, V: Viscosity, Fla. Score: Flavour score, Text Score: Texture score, OAA Score: overall acceptability score, RSM- Value from RSM, Act.- Actual calculated value, Dev.- deviation

**Table 7: Viscosity, pH, TSS and  $W_a$  Values of Strawberry and Pineapple Fruit Ripple**

		Viscosity at 10°C (Pa.s)	pH	TSS (°Brix)	$W_a$
Strawberry fruit ripple (Control)	Freshly prepared	0.60	3.42	55	0.9756
	Freeze thaw	1.53	3.14	58	0.9443
Strawberry fruit ripple (Test)	Freshly prepared	0.528	3.88	54	0.9427
	Freeze thaw	1.01	3.66	57	0.9030
Pineapple fruit ripple (Control)	Freshly prepared	0.679	3.56	53	0.9842
	Freeze thaw	0.725	3.21	57.2	0.9375
Pineapple fruit ripple (Test)	Freshly prepared	0.728	3.98	49	0.9400
	Freeze thaw	0.834	3.54	54.5	0.9157

**Table 8: Physico-Chemical Properties of Strawberry and Pineapple Fruit Ripple Premix**

Properties	g/100 g of Strawberry Fruit Ripple Premix	Energy Kcal/100 g of Strawberry Fruit Ripple Premix	g/100 g of Pineapple Fruit Ripple Premix	Energy Kcal/100 g of Pineapple Fruit Ripple Premix
Fat	0.29	2.61	0.26	2.34
Protein	2.18	8.72	1	4
Carbohydrate	89.27	357.08	87.96	351.84
Sugar	83.33		87.96	
Total energy		368.41		358.18
Total moisture	4.87		3.58	
Total ash	3.29		3.25	

